

Game-Based Education and Training

DARPA SBIR 12.1 Topic 003, Joint Dept. of ED and DARPA
JD13.1 Topic 003 & Topic 004

Education and training applications for First Responders, Foreign language and cultural proficiency, and Computer Science skills among military and civilian personnel have long been important to the Department of Defense.

Russell D. Shilling, PhD, CAPT, MSC, USN
DARPA Program Manager
russell.shilling@darpa.mil

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DARPA's SBIR/STTR Program

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DARPA's mission is to prevent technological surprise for the United States and to create technological surprise for its adversaries.

The DARPA SBIR and STTR Programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.

I.) PROGRAM OVERVIEW

A. Introduction

The goals of the programs discussed in this document are to explore new and innovative applications of game-based technologies to encourage and enhance life-long learning, procedural learning, and technical skills which are critical for military success in the 21st century.

The topic of "game-based education and training" is gaining considerable attention as more and more children and adults are learning from games. Recognizing this trend, instructors are leveraging the power of games to engage students both inside and outside of the classroom. Well-designed games can motivate students to actively engage in meaningful and challenging tasks, to learn content, and sharpen critical-thinking and problem-solving skills. Education gaming experts have identified some of the key features of games that may have the greatest potential to impact student learning. These features include: exciting narratives and video-game quality graphics that motivate and engage students, challenging discovery-based tasks, adaptive supports that adjust to and support individual learners, formative assessment, multiplayer functionality, and competition and rewards. With the advent of modern web-based delivery mechanisms (e.g., handheld personal digital assistants, tablet personal computers) games are now available to users anytime and anywhere. Thus, the momentum for games is likely to continue and we will see them actively integrated into military curricula.

B. SBIR Program Description

The purpose of the Small Business Innovation Research (SBIR) program is to stimulate technological innovation in the private sector, strengthen the role of small business in meeting research and development needs, increase the commercial potential of Federally-supported research results, and improve the return on investment from Federally-funded research for economic and social benefits to the Nation.

The SBIR program consists of three phases, as described below.

Phase I – Phase I is to determine, insofar as possible, the scientific or technical merit of ideas submitted under the SBIR program. The proposal should concentrate on R/R&D that will establish the usability of a prototype and initial feasibility of the concept, a prerequisite for further support in Phase II.

Phase II – Phase II is to expand on the results of and to further pursue the development of Phase I projects. Phase II is the principal R/R&D effort. It requires a more comprehensive plan that outlines the effort in detail and describes the commercial potential of the game-based education & training system(s).

Phase III – Phase III is the delivery of mature toolset system(s) that would be transitioned (delivered and/or deployed) and integrated into a military/commercial game-based education & training system(s).

The following three SBIR topics present the current status of the research by the performer(s) under each specific SBIR topic related to game-based education and training research efforts.

II.) SBIR 12.2 Topic 003 Phase II (*First-Responder*)

Develop a mobile application that uses innovative game-based strategies and visualization techniques to teach medical first-responder skills combined with intelligent tutoring systems to teach underlying learning principles. Game design, architecture, and research approach should allow for the optimization of pedagogical approaches based on performance of the individual learner and across a large population of users.

The research is currently at the PHASE II level. The Performer, Intific, Inc., provides the following individual snapshot status of their progress in ongoing research to date.

KEYWORDS: Medical training and simulation, intelligent tutors, education, pedagogy, gameplay, video games, mobile device, IOS, ANDROID, medics, corpsmen

A.) Intific, Inc.: Space Doc

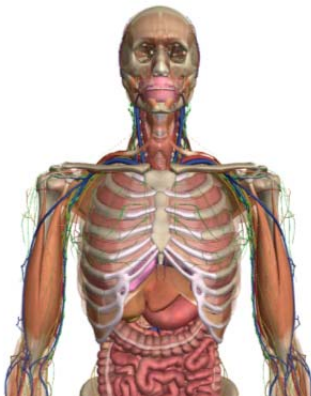
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Space Doc is a Phase II SBIR 12.2 Topic 003 project focused on creating a mobile, web-based learning and medical training application set in a persistent world with a highly relevant science fiction / science-fact emphasis. Travel on a mission to Mars aboard a ship with 50-plus teammates on a long journey with dangers of every type threatening mission success. Play as a first

responder trainee with team members counting on *your* help to keep them alive. Those rescued through your efforts are 'unlocked' in the game-based experience for future access while they teach relevant learning topics and first responder procedures.

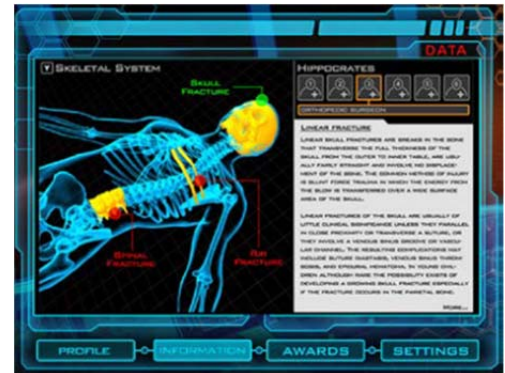
Space Doc merges this game-based approach to educational learning with realistic physiology system simulation and leverages novel use of mobile interfaces to maximum effect. Scores are based on both lives saved and knowledge acquired. Players advance as experience adds up, unlocking more difficult dangers to deal with. Using tools and infrastructure that leverages ongoing work with DARPA's ENGAGE Program, the technology provides an Information, Action, and ultimately an Exploration Mode and readily supports tailored learning and training, either based on adaptive proficiency or in scenarios customized for the needs of an audience.



Space Doc combines human physiology and biology learning with medical training in an application set within the futuristic experience of space travel and medical science to enhance player immersion. While journeying to Mars on your ship of over 50 team members (Non Player Characters), the long journey presents a continual series of medical emergencies that threaten the mission to ultimately build Mars habitats. Players must help keep their crew members alive, and to do that they must learn how the human body works and how to treat medical traumas that test their mastery of the learning material. Rescued teammates can

dynamically provide data, encouragement, technologies, and tips regarding increasingly advanced techniques. To accelerate development and enhance accuracy, Intific will be using the high-resolution Zygote 3D medical body models. These assets provide excellent flexibility in illustrating a wide range of potential injuries from unlimited viewpoints.

Information Mode is the recurring learning mode and offers a futuristic Graphical User Interface (GUI) that permits players to review data in bite-sized pieces as they earn and collect it. This is where players obtain both learning materials and first responder information. This database of all the collected knowledge can be also accessed in Action Mode (below) whenever the device is turned to this view. (It is also available as a window on a player profile screen, not shown here.) This is the central data bank where everything is collected and can be reviewed at any time in the game. When players are out exploring the ship, the portable TriCorder can access this data and gather more. This information can also be viewed during any trauma event when players are required to perform first responder duties, but it will pay to learn in advance since players will be under time pressure when treating a patient in need of emergency care. Intific introduces this interface early in the overall experience because it is the most complex one in the game. It will include all 5 scenarios within the prototype (Choking from Injury, Sucking Chest Wound, Controlling Bleeding from Accident, Circulatory Support, and Head Wound), and will be filled in as sequential material is unlocked through player collection and successful patient treatment activities. This full database is built early and is simply unlocked during play.



Action Mode is the key recurring play mode that allows the player to deal with any medical emergency. This is where players must apply their learning in the treatment of serious medical crises. This drag-and-drop game approach includes realistic simulation of physiology systems and permits use of mobile interfaces in new ways without introducing negative training effects. Scores and awards are based upon patient lives saved and knowledge gained. Players advance as experience grows, unlocking increasingly difficult medical cases.



The core principle that motivates this design approach is that *every* human life has value; individual human beings are not medical cases, actuarial tables, or statistics. We are all valuable in our own right and your survival is collectively important. This design philosophy makes Intific's approach unique, as it not only provides a vehicle for the integration of knowledge and practice, but it also gives a new perspective on the ethical and practical responsibilities of first responders. This philosophy is further reinforced by NPCs who mentor and assist players. Further, this approach permits Intific to use the game

structure to create a strong connection between scientific learning and Social-Emotional Learning principles, making ***Space Doc*** a compelling training and learning package.

III.) SBIR JD13.1 Topic 003 Phase I (*Neuroplastic Games for Foreign Language Learning*)

Foreign language and cultural proficiency among military and civilian personnel have long been important to the Department of Defense. Such proficiency promotes sensitivities that are necessary for

the demands of the 21st Century. Although humans can learn new languages at any point in their lifespan, it is much easier to acquire new languages early in life. It has also been shown that once the brain is primed to learn a new language, it is easier to acquire additional languages later in life.

The research is currently at the PHASE I level. There are 3 research performers under contracts working on different solutions to this problem space. Studio Kinection, Make My Own Designs, and Muzzy Lane Software provide the following individual snapshot status of their progress in ongoing research to date.

KEYWORDS: Foreign language teaching and learning, intelligent tutors, education, pedagogy, games, video games, mobile device, IOS/ANDROID applications.

A.) Studio Kinection, Inc.: Language Quest

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LANGUAGE QUEST

Concept

Language Quest uses mobile games to accelerate the development of language-learning skills in elementary school students. Based on research in bilingualism, cognitive neuroscience, and usage-based linguistics, the program targets five specific executive functions critical to the ability to perceive, differentiate, and reproduce both spoken and written linguistic forms. The basic skills developed through the program can be applied to any language that students choose to learn in the future.

Capabilities and Objective

The program takes a holistic approach that focuses on discrete language learning abilities, and embeds these in higher level quests and larger narratives that provide students with compelling reasons (adventure, discovery, team work, competition) to be successful. The games and attendant materials are also designed so that students are affectively motivated to explore and learn about world languages and cultures which is hoped will forge a disposition to make learning world languages a life long pursuit.

Kinection has found Usage-based Linguistics (UBL) to be a helpful framework in mapping cognitive functions research onto the development of language learning skills. UBL emphasizes that all human languages are comprised of types of recurrent patterns. After introducing linguistic materials and patterns, Language Quest provides feedback that entrenches positive pattern recognition while preempting or correcting errors. Mini games and adventure activities are designed to enhance learner

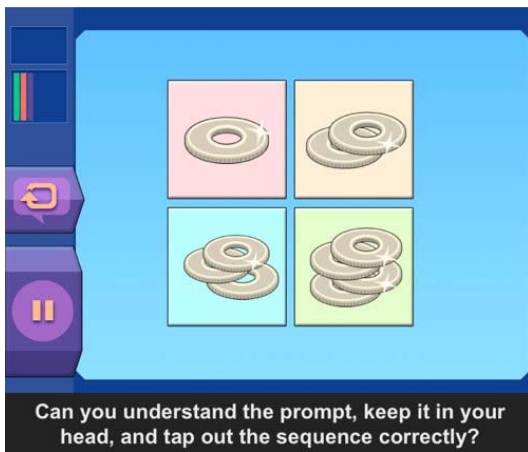
abilities for schematization and analogy, fundamental cognitive processes that enable the generalization of discrete instances of language use to broader patterns and constructions.

Age Group Focus

The initial version of Language Quest is targeted at the middle years of elementary school (3rd and 4th grades). The modular structure of the program makes it easily extensible to both younger and older students. A version focused on developing linguistic skills in adults could be easily adapted by changing the story theme and art style, while preserving the current game mechanics and interaction design.

Research Project Status

As of October 2013 (Phase 1), an overall program architecture has been completed, as well as designs for multiple quests and minigames. In the quests, students meet characters from local cultures and complete tasks with them in order to progress through the story. As they proceed, they unlock mini games and other rewards. Mini games focus on specific skills that contribute towards language learning



ability, such as sound discrimination, character recognition, metalinguistic awareness, and syntax flexibility. The games support a broad range of listening, speaking, reading, and writing skills.

Kinection is currently in the process of building playable versions of the quests and games and testing these to refine the game mechanics and tailor the gameplay experience to the audience.

For more information on the Language Quest project, please contact Doug Nelson at Kinection: doug@kinection.com

B.) Make My Own Designs, LLC: "SpeakAgent".

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SpeakAgent is a series of touch-screen games for learners in grades K-5 to develop long-lasting phonological awareness and processing in second languages, with a side benefit of also acquiring basic syntax and receptive vocabulary. The game takes advantage of recent findings in the emerging field of developmental neurolinguistics to advance beyond the current state of the art, in partnership with leading experts such as Dr. Jo Anne Kleifgen, co-director of the Center for Multiple Languages and Literacies at Teachers College, Columbia University.

Today's Computer-Assisted Language Learning (CALL) products are not meeting the needs of young learners in four ways:

1. They target either a Pre-K audience or 6th grade and above, but not the K-5 market.

2. They generally use a direct instruction method that features artificially constructed “units” or lessons bereft of cultural context, rather than using natural situations and interactions.
3. They tend to focus on reading, syntax and language production at the expense of phonology, using a vocabulary set that does not apply to the real world of kids.
4. They often fail to engage young learners.

SpeakAgent is a platform designed to address these gaps: (1) It is designed to serve grades K-5 and, based on the development team’s experience at PBS KIDS and Houghton Mifflin Harcourt, is further segmented for grades K-2 and 3-5. K-5 is a time during which the brain is still highly neuroplastic (see Fig. 1), but where the child has the skills to master challenging new material in a game format. (2) SpeakAgent aims to immerse learners in an engaging game environment that helps them to acquire meaning naturally through self-directed, culturally relevant play and dialog. Learners can also use SpeakAgent’s unique Phrase Builder to experiment with word and sound combinations and see how characters react, creating statistical learning opportunities available on no other platform. (3) SpeakAgent’s experiential, auditory approach seeks to develop phonological awareness and word recognition, creating long-lasting changes to the brain that will make learning languages easier later in life. Instead of choosing words and sounds used by adults, SpeakAgent focuses on the core vocabulary used by native speakers at 36 to 60 months. (4) By creating engaging games targeted to narrow age bands (K-2 & 3-5), together with a compelling narrative, SpeakAgent aims to make learning the phonology of new languages engaging and fun.

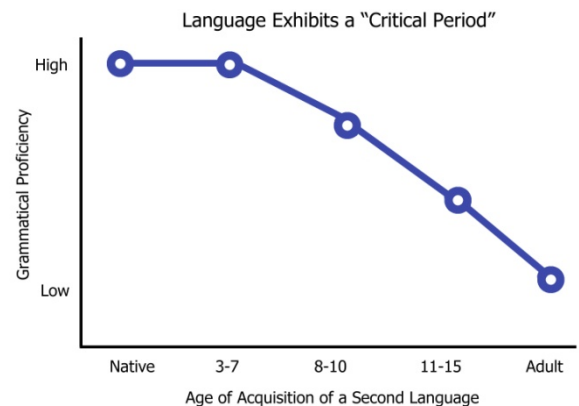
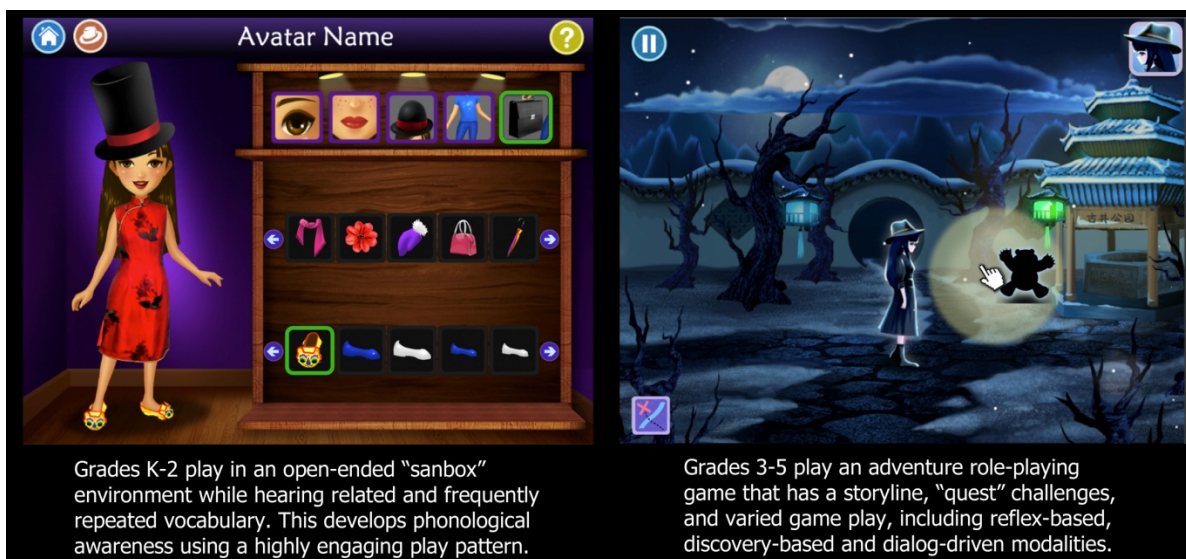


Figure 1: The Relationship between Age of Acquisition of a Second Language and Language Skill
Adapted from Johnson and Newport(1989).



Continuous Improvement Approach

SpeakAgent uses player behavioral data to analyze the best path for learning. It aims to learn over time what specific behaviors and sequences result in measurable learning progress and optimize the play styles, sequences and word sounds, forms and classes to most quickly derive the best outcomes for a specific target language. (For example, we may find that exposure to certain phonemes makes for the optimal starting point.) SpeakAgent would allow A/B testing on several such dimensions. SpeakAgent also has a ground-breaking research plan for Phase II that intends to test for neuroplastic changes in young children and determine the speed of acquisition and the extent to which changes persist over time. The type of electroencephalography (EEG) testing to measure phonological processing has never before been performed with a language learning game.

C.) Muzzy Lane Software:

NELL; A game to promote neuroplasticity in early language learning

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For decades, studies have shown that young children have a unique ability to rapidly acquire new language skills. Today's researchers from neuroscience, psycholinguistics, and second language acquisition have been able to locate the biological foundations of this ability and measure the cognitive benefits associated with it, gaining a better understanding of the brain processes and the overall benefits bilinguals exhibit in executive functioning and general learning.

Our project aims to create an interactive game for children ages 6-9 that will immerse them in a naturalistic language environment in order to enhance their ability to distinguish new sounds and structures, helping to 'prime the brain' for language learning experiences.

Research shows that when specific

language learning pathways are established in the brain at an early age, those pathways can facilitate the building of new language connections later in life. We hope to replicate the thinking process that young bilinguals experience: balancing knowledge of two different languages at the same time and having the mental flexibility to choose between them in a given situation. NELL would provide players with practice in these mental balancing skills by focusing on a variety of unique sounds and grammatical structures from several stylized



languages in order to generalize the learning behaviors involved in natural language acquisition.”

Since language acquisition occurs best in a social setting with task-based activities, Muzzy Lane Software's game aims to feature a multi-player, tablet-based format where children work together to solve problems. Players would decipher and understand new language words and use them to communicate with game characters to complete missions. By scaffolding their understanding of sounds, words and then sentences through different levels of game play, children would gain metalinguistic awareness, or an understanding of language components and the rules that govern them.

The Game Design: In the game, players would play the role of a space explorer. Arriving at a new planet, they receive a message in an unknown language. Unable to understand the message, the player descends to the planet and, with the help of “CHAT”, the talking computer in their spacesuit, they interact with friendly aliens on the planet to learn some of their language, and decode the messages.

The game would feature multiple planets and aliens, each with different languages – so players would have the chance to compare and work with sounds and structures across multiple languages. This experience with multiple languages has been shown to be a factor in bilingual children's abilities to more easily learn additional languages.



In an early level, players will “collect” alien sounds from sentences the alien speaks (with help from CHAT), and combine the sounds to form words. Each sound will be represented by a memorable symbol, and the symbols combined to create simple words. The player then “speaks” the word to the alien, and the alien will (with pictures) help teach the word's meaning.

The game would provide multiple ways for players to interact with language with the aliens, starting with learning phonemes, then putting those together to form words, learning the meanings of words from the aliens, and working out how the words go together in different ways to form simple questions and statements.

The completed game would utilize voice recognition to enable players to actually “speak” alien words as part of the gameplay. In multiplayer mode, two players would communicate with each other (in the “alien” language they have learned) to complete tasks together.

Testing: To measure the effectiveness of the project, Muzzy Lane Software intends to evaluate several features of the language learning process. Assessments of metalinguistic awareness would measure how well children became aware of language function through game play and how well they can apply their newly acquired language skills to a novel

situation. Since bilingual children also demonstrate measureable increases in executive functioning (EF) skills (i.e. working memory, distraction avoidance, etc.) Muzzy Lane Software intends to assess EF skills with both pre- and post-tests, and possibly conduct fMRI or EEG studies to examine how the game affects the language-learning center of the brain.



Concept art for player space-explorer Avatar and two Aliens, with one alien 3D model in process.

IV.) SBIR JD13.1 Topic 004 Phase I (Hybrid Videogame/ Graphic Novel to Support CS Education)

Learning a new programming language can be difficult for first-time students. Learning to program robots introduces additional challenges since it involves more than just learning a programming language. Students must also understand principles of physics and mathematics. Game-based computer simulations can provide dynamic physical representations of environments in which robots can interact, but do not naturally provide the ability to provide instruction in areas such as mathematics and computer logic that require sequential processes.

The research is currently at the PHASE I level. There are 3 research performers under contracts working on different solutions to this problem space. Tietronix Software, Triad Interactive Media, Inc., Intific Inc. provides the following individual snapshot status of their progress in ongoing research to date.

KEYWORDS: Graphic Novel, Sequential Art, Web, Storytelling,, Impact Comics, Graphic Novel Art, Memories.

A.) Tietronix Software: Aegis

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To maintain competitiveness in the workforce students need to possess more than content knowledge; students must be skilled in critical thinking, problem solving, and analysis. By implementing active engagement techniques in the classroom, such as video games and robotics, educators can engage students and offer motivation to progress through the learning process.

Tietronix is developing a software prototype that combines an interactive strategy game with a graphic novel-inspired interface. *Aegis* is a standards-based video game designed primarily to engage students in computer science and programming through graphic novel-style storytelling, interactive gameplay and robotics concepts. Players can immerse themselves in a learning environment as they follow a sequential story, interact with characters, build onscreen robots, and design programming logic to carry out inquiry missions.

The *Aegis* project's overall goal is to address educational standards and produce a research-based classroom tool that supports active student engagement and instruction in integrated math and science, while promoting growth in critical thinking. *Aegis* would be developed as a complete classroom package with three sections: 1) an interactive 2D Graphic Novel which leads the story of *Aegis* and provides content knowledge for robotics programming, math and science, 2) a drag and drop Programming Laboratory that helps students learn programming logic and familiarity with syntax while developing code for their robots, and 3) a Game Play Arena that allows students to "test-drive" their code in a 3D high-quality game environment without need for classroom space or a robotics kit.

The *Aegis* project intends to contribute to, and advance, the body of knowledge in robotics and



Figure 2 – In-Game Robotics Laboratory

programming learning research technologies. Using a video game environment with dynamic interaction and sequential art, Tietronix seeks to engage students directly and provide an easy framework for them to apply

the math, science, and programming logic required to build valuable skills. The game would be developed for mobile platforms, as well as desktop computers in the classroom.

Tietronix has partnered with University of Houston-Clear Lake faculty for instructional technology consultation on the educational components within *Aegis*. Houston area robotics coaches for 6-8 grades, as well as NASA robotics

experts have also volunteered their time. In-classroom research opportunities are scheduled

to be conducted during Phase II with Deer Park ISD, with their junior computer science classroom and robotic team.



Figure 3 – Drag/Drop Robot Build Screen

B.) Triad Interactive Media, Inc. “Blackfeather: Adventures in Programming and Robotics”

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Blackfeather: Adventures in Programming and Robotics is a hybrid graphic novel/video game that aims to use robotics to teach computer science to middle school students. Funded by DARPA's SBIR initiative aimed at encouraging more U.S. students to enter the field of computer science, Blackfeather is being developed by Triad Interactive Media, Inc., a North Carolina firm that specializes in game-based education and training in science, technology, and mathematics.



Our heroine, Sabrina*

Blackfeather is a prototype project to provide students with skills in Java programming. Gaming elements in conjunction

with an engaging narrative aim to grab students' interest, robotics activities seek to apply programming to problem-solving tasks, and the combination of game, narrative, and application of learning is designed to promote transfer and retention of learning. All materials are browser-based and capable of being accessed on various platforms and devices, including computers, tablets, and smart phones.



Blackfeather*

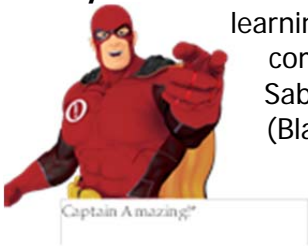
Coding Instruction. The programming language being taught is Java because it a good beginner's programming language that has fewer coding pitfalls than C++ and would provide learners with introductory programming skillsets that would benefit them when they go on to take high school AP and higher education introductory computer programming courses.

Gaming. Game-based education and training programs can be highly effective means of teaching complex content like programming, particularly for today's generation of student (“digital natives”),

who have grown up playing games. Games have the power to totally immerse students in an activity, increase their time on task, and therefore enhance their performance. The rich interactive environment of game-based technology:

- Holds students' attention and encourages them to "play and learn" longer
- Provides them with feedback on their responses
- Gives computer-based assessments of their progress
- Makes real-time adjustments to alter the difficulty level of a task to suit their pace of learning,
- Appeals to multiple learning styles because game-based education and training is multimedia, multi-sensory, and multifaceted, and
- Results in improved understanding and performance.

Graphic Novel. An overarching narrative in the form of a graphic novel integrates the elements of the learning system and provides students with an engaging story. The narrative concerns a competition between a superhero, Captain Amazing, and a 14-year-old whiz kid Sabrina. To put the arrogant Captain Amazing in his place, Sabrina builds a robot (Blackfeather) and eventually is able to program Blackfeather to outmaneuver and subdue Captain Amazing. However, in the absence of the superhero, villains overrun the city, so Blackfeather releases Amazing, and the two work together to overpower the villains. At the conclusion, Captain Amazing becomes more humble, and Sabrina is acknowledged for her accomplishments. The story and action are entertaining, age appropriate, and nonviolent.



The choice of a middle school female as the protagonist was intentional. Because females are grossly underrepresented in computing professions, one goal of the project is to entice girls to explore coding and show them it can be a viable career path.

Robotics. On the robotics side, Triad has selected a commercial kit that is designed for youngsters 10 and up and allows them to construct one of numerous variations of a robot. The kit comes with all necessary parts, including motors, smart sensors, and wireless Blue Tooth. Once the robot is assembled, students apply their skills in computing to program the bot to solve problems consistent with the narrative.



Algorithm Game from Blackfeather*

Project Status. The prototype chapter, which focuses on algorithms, has been completed. It consists of instructional materials that teach coding, integration of robotics, the accompanying chapter of the graphic novel, and a fully functional series of game-based activities. In addition, the Triad team created the script and artwork for the entire graphic novel, drafted Java instruction for all 8 units, and completed robotics instructions. As part of the next phase, Triad intends to team with Robotics Clubs across the country to evaluate the Blackfeather program, it would be revised based on feedback, and then the polished product will be marketed and distributed.



The Blackfeather logo*

Next Steps. Having created all tasks in Phase I, the Triad team is set to begin work on developing the other 7 units in the project, using the prototype chapter as a model. The prototype spells out the concept, media, functions, aesthetics, graphics, story, and instructions materials that would be followed in the development of the extended project.

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C.) Intific Inc. "Looking Glass"

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Looking Glass is a Phase I SBIR effort with the goal of crafting an immersive, story-driven game experience that enables computer science education for 6-8th grade students. It presents learning in a game-based series of challenging levels that permit a high degree of player choice in tailoring their educational progression and offers adapting game systems that present both academic and social emotional learning interactions. Gameplay occurs within a futuristic Wonderland, where proficiency in computer programming activities unlocks level and knowledge progression. Game levels are created using a toolkit approach that makes iteration and additions easy and cost effective.

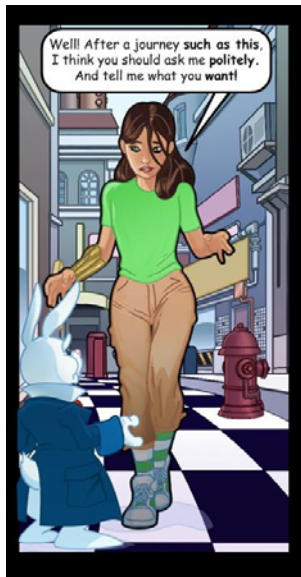
In-game student programming activities are conducted virtually and downloadable to the popular Lego Mindstorms EV3 robots for classroom presentation and evaluation. Designed and implemented by veteran game and educational experts, **Looking Glass** embeds metrics and data collection systems for researchers to validate, refine and improve educational outcomes. The game system seeks to offer innovative game approaches, interesting game characters, and a level of engagement designed to ultimately carry across the entire K-12 spectrum as the story unfolds. With proven delivery systems, informed by ongoing research to crowdsource with thousands of students, and building upon a franchise concept to unify a diversity of learning and programming experiences, **Looking Glass** is designed to help revolutionize Computer Science education.

Dr. Seuss once said, "Fantasy is a necessary ingredient in living, it's a way of looking at life through the wrong end of a telescope." **Looking Glass** contemporizes the compelling fantasy worlds of Lewis Carroll's *Alice in Wonderland* and *Through the Looking-Glass* as a unifying game fiction in which the White Rabbit and other characters guide students through computer science principles with interactive graphic novel screens unlocked through play to reveal an ever-deeper series of story revelations and plot twists that we expect from episodic storytelling.



Creation of a digital Wonderland allows Intific to create an ongoing game world of visual variety and ever-changing gameplay that evolves as it addresses the learning requirements of computer science over many school years. This meta-story unifies a multi-year experience as the programming challenges and overall visual treatment of the in-game and graphic novel art sets grow more mature, complex, and realistic over time. All text used in the graphic novel interstitials and the presentation of learning materials would be age-appropriate, as will the Social-Emotional Learning challenges embedded in particular mini-games and vignettes. Audio is used for engaging sound effects and music where appropriate.

The game begins with an introductory graphic novel interstitial that opens the game worlds of



Wonderland to players. Each student has a Player Profile page, a combined scrapbook of scores and a journal where they can evaluate their progress and knowledge. Students also create a customized Alice/Alex avatar to represent them in the graphic novel pages. The White Rabbit then leads players to a number of entry-level game exercises so learning can be influenced by the student's choices along their learning path.

Each **Looking Glass** game level starts with a graphic novel interstitial to set up the learning challenge, accent concepts, provide integrated help, and offer learning scaffolding. Three different types of high-quality game experiences are always offered: **Discovery**, **Exploration**, and **Creation** games, each with targeted Computer Science Teachers Association (CSTA)-based learning objectives. The game in each level uses drag and drop interactive conventions to encourage students to engage with code, explore by testing predictions, visualize flow, elaborate by application, and evaluate to demonstrate understanding of a concept or skill. All of this data is automatically captured by the game system.

A conclusive graphic novel interstitial ends each game level, with results posted to the Player Profile and Community Leaderboard to encourage multi-player competitive or cooperative dynamics. This process continues as players unlock new 'rabbit holes' to reveal new learning topics. This level-based approach allows students to take many paths through the solution space, becoming, in essence, a story in which the students are characters focused on unlocking their own story while solving each computer science challenge. The game would be structured such that there are well-defined learning objectives and quantifiable measures of learning success throughout.

V.) CONCLUSION

PROGRAM SUMMARY

The SBIR research initiatives are accomplishing much in bringing together research scientists, educators, software developers and graphic novelists to create a new research community that did not previously exist. Game design, architecture, and research approach has allowed for the optimization of pedagogical approaches based on performance of the individual learner and across a large population of users. In December 2012, DARPA and the Department of Education issued a joint SBIR solicitation (ED-IES-13-R-0008) that included a request to develop computer science education tools that were hybrids of graphic novels and videogames. Foreign language and cultural proficiency among military and civilian personnel have long been important to the Department of Defense. Such proficiency promotes sensitivities that are necessary for the demands of the 21st Century. Although humans can learn new languages at any point in their lifespan, it is much easier to acquire new languages early in life. It has also been shown that once the brain is primed to learn a new language, it is easier to acquire additional languages later in life. Learning a new programming language can be difficult for first-time students. Learning to program robots, introduces additional challenges since it involves more than just learning a programming language. Students must also understand principles of physics and

mathematics. Game-based computer simulations can provide dynamic physical representations of environments in which robots can interact, but do not naturally provide the ability to provide instruction in areas such as mathematics and computer logic that require sequential processes.

Within these SBIR programs, we have started referring to the use of these approaches as “Serious Comics” or “Impact Comics”. The ultimate effectiveness of these programs will help determine if these techniques can be developed similarly to “Serious Games” which have been widely and successfully adopted across both the military and civilian sectors over the past decade to enhance training, education, and health.

TRANSITION PLAN

This process started when DARPA issued the SBIR Topic call for proposals. The performers were instructed to begin looking for transition partners from day one of the Phase 1 effort. By the conclusion of the research effort under Phase 2 contracts, the performers are expected to have found transition partners and outside funding vehicles or amendments to those in the DoD Military Services and/or alternate partners in the commercial sector. The outside sources would fund continued research and integrate it into day-to-day use.

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